

Product Specification

SPECIFICATION FOR APPROVAL

(●) Preliminary Specification
 () Final Specification

| | |
|--------------|------------------------------|
| Title | 21.5" Full HD TFT LCD |
|--------------|------------------------------|

| | |
|-------|----|
| BUYER | HP |
| MODEL | |

| | |
|----------|----------------------|
| SUPPLIER | LG Display Co., Ltd. |
| *MODEL | LM215WF2 |
| SUFFIX | SLB1 |

*When you obtain standard approval,
 please use the above model name without suffix

| APPROVED BY | SIGNATURE DATE |
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| Please return 1 copy for your confirmation with your signature and comments. | |

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RECORD OF REVISIONS

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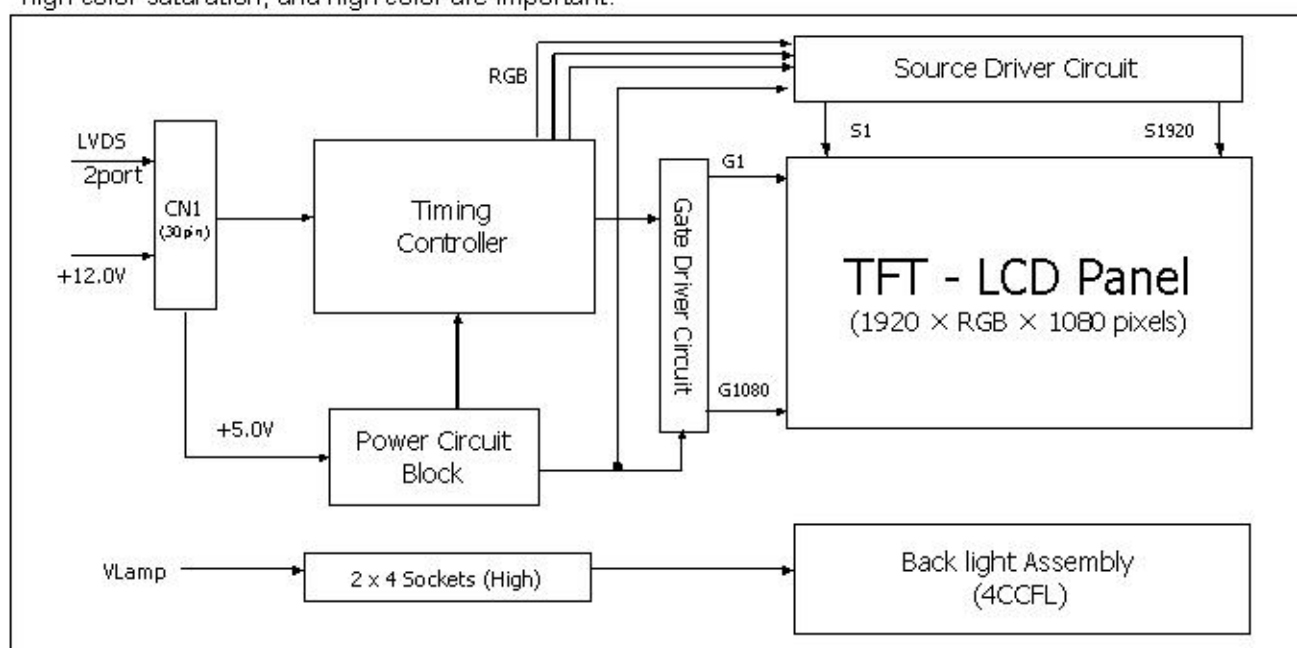
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1. General Description

LM215WF2 is a Color Active Matrix Liquid Crystal Display with an integral Cold Cathode Fluorescent Lamp(CCFL) backlight system. The matrix employs a-Si Thin Film Transistor as the active element. It is a transmissive type display operating in the normally black mode. It has a 21.5 inch diagonally measured active display area with FHD resolution (1080 vertical by 1920horizontal pixel array) Each pixel is divided into Red, Green and Blue sub-pixels or dots which are arranged in vertical stripes. Gray scale or the brightness of the sub-pixel color is determined with a 8-bit gray scale signal for each dot, thus, presenting a palette of more than 16,7M colors with A-FRC(Advanced Frame Rate Control).

It has been designed to apply the 8Bit 2 port LVDS interface.

It is intended to support displays where high brightness, super wide viewing angle, high color saturation, and high color are important.



[Figure 1] Block diagram

General Features

| | |
|------------------------|---|
| Active Screen Size | 21.46 inches(545.22mm) diagonal |
| Outline Dimension | 495.6(H) × 292.2(V) × 16.5(D) mm (Typ.) |
| Pixel Pitch | 0.2475 mm × 0.2475mm |
| Pixel Format | 1920 horiz. By 1080 vert. Pixels RGB stripes arrangement |
| Color Depth | 16,7M colors |
| Luminance, White | 250 cd/m ² (1point) |
| Viewing Angle(CR> 10) | View Angle Free (R/L 178(Typ.), U/D 178(Typ.)) |
| Power Consumption | Total TBD Watt (Typ.) (TBD Watt @V _{Lcd} , TBD Watt @250cd/m ²) |
| Weight | 2450 g (typ.) |
| Display Operating Mode | Transmissive mode, normally black |
| Surface Treatment | Hard coating(3H), Glare treatment of the front polarizer |

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2. Absolute Maximum Ratings

The following are maximum values which, if exceeded, may cause faulty operation or damage to the unit.

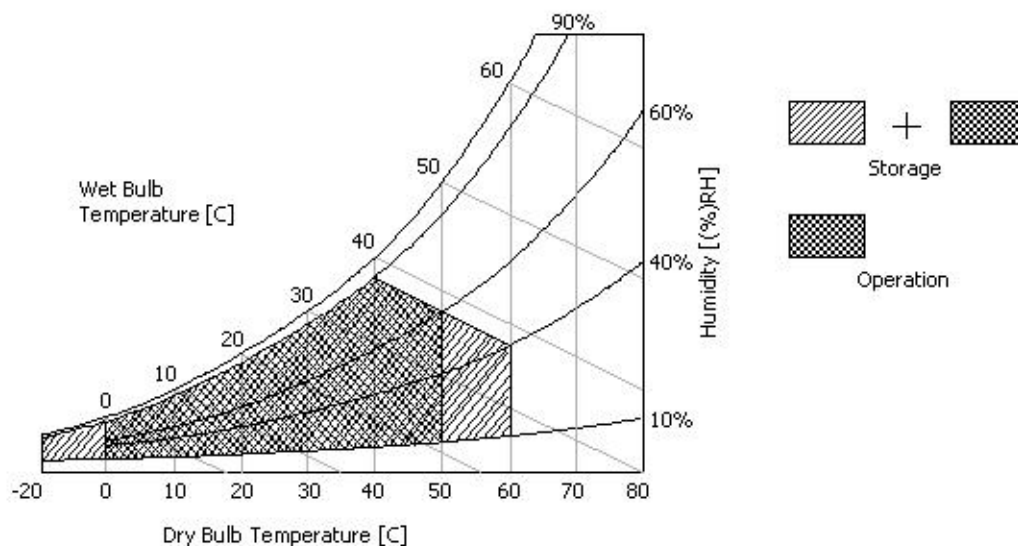
Table 1. ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | Values | | Units | Notes |
|----------------------------|------------------|--------|-----|-----------------|-------------|
| | | Min | Max | | |
| Power Input Voltage | V _{LCD} | -0.3 | 14 | V _{dc} | at 25 ± 2°C |
| Operating Temperature | T _{OP} | 0 | 50 | °C | 1, 2 |
| Storage Temperature | T _{ST} | -20 | 60 | °C | |
| Operating Ambient Humidity | H _{OP} | 10 | 90 | %RH | |
| Storage Humidity | H _{ST} | 10 | 90 | %RH | |

Note : 1. Temperature and relative humidity range are shown in the figure below.

Wet bulb temperature should be 39 °C Max, and no condensation of water.

Note : 2. Maximum Storage Humidity is up to 40°C, 70% RH only for 4 corner light leakage Mura.



[Figure 2] Temperature and relative humidity

Product Specification
3. Electrical Specifications
3-1. Electrical Characteristics

It requires two power inputs. One is employed to power the LCD electronics and to drive the TFT array and liquid crystal. The second input power for the CCFL, is typically generated by an inverter. The inverter is an external unit to the LCDs.

Table 2. ELECTRICAL CHARACTERISTICS

| Parameter | | Symbol | Values | | | Unit | Notes |
|-------------------------------|----------|-------------------|----------------|----------------|-----------------|-------------------|-------|
| | | | Min | Typ | Max | | |
| MODULE : | | | | | | | |
| Power Supply Input Voltage | | V _{LCD} | 11.4 | 12 | 12.6 | V _{dc} | |
| Permissive Power Input Ripple | | V _{RF} | - | - | 100 | mV | 13 |
| Power Supply Input Current | | I _{LCD} | | | | mA | 1 |
| | | | | | | mA | 2 |
| Differential Impedance | | Z _m | 90 | 100 | 110 | ohm | |
| Power Consumption | | P _{LCD} | | | | Watt | 1 |
| | | P _{LCD} | | TBD | | Watt | 2 |
| Rush current | | I _{RUSH} | - | - | 3 | A | 3 |
| LAMP : | | | | | | | |
| Operating Voltage | | V _{BL} | 780 (8.0mA) | 800 (7.5mA) | 1000 (2.5mA) | V _{RMS} | 4, 5 |
| Operating Current | | I _{BL} | 2.5 | 7.5 | 8.0 | mA _{RMS} | 4 |
| Established Starting Voltage | | V _s | | | | | 4, 6 |
| | at 25 °C | | | | 1250 | V _{RMS} | |
| | at 0 °C | | | | 1550 | V _{RMS} | |
| Operating Frequency | | f _{BL} | 40 | - | 70 | kHz | 7 |
| Discharge Stabilization Time | | T _s | | | 3 | Min | 4, 8 |
| Power Consumption | | P _{BL} | | 24 | 26.4 | Watt | 9 |
| Life Time | | | 50,000 | | | Hrs | 4, 10 |

Note : The design of the inverter must have specifications for the lamp in LCD Assembly.

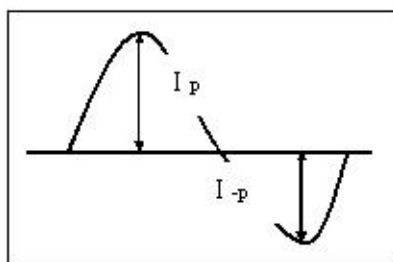
The performance of the Lamp in LCM, for example life time or brightness, is extremely influenced by the characteristics of the DC-AC inverter. So all the parameters of an inverter should be carefully designed so as not to produce too much leakage current from high-voltage output of the inverter.

When you design or order the inverter, please make sure unwanted lighting caused by the mismatch of the lamp and the inverter (no lighting, flicker, etc) never occurs. When you confirm it, the LCD-Assembly should be operated in the same condition as installed in you instrument.

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Note. Do not attach a conducting tape to lamp connecting wire. If the lamp wire attach to a conducting tape, TFT-LCD Module has a low luminance and the inverter has abnormal action. Because leakage current is occurred between lamp wire and conducting tape.

1. The specified current and power consumption are under the $V_{LCD}=12V$, $25 \pm 2^{\circ}C$, $f_v=60Hz$ condition whereas mosaic pattern(8×6) is displayed and f_v is the frame frequency.
2. The current is specified at the maximum current pattern.
3. The duration of rush current is about 5ms and rising time of power Input is $500\mu s \pm 20\%$.(min.).
4. Specified values are for a single lamp.
5. Operating voltage is measured at $25 \pm 2^{\circ}C$, and follows as below condition.
 The variance of the voltage is $\pm 10\%$. (Based on single Lamp.)
 The variance of the voltage is $\pm 20\%$. (Based on system & Test equipment tolerance.)
6. The voltage above V_g should be applied to the lamps for more than 1 second for start-up.
 (Inverter open voltage must be more than lamp starting voltage.)
 Otherwise, the lamps may not be turned on. The used lamp current is the lamp typical current.
7. The output of the inverter must have symmetrical(negative and positive) voltage waveform and symmetrical current waveform (Unsymmetrical ratio is less than 10%). Please do not use the inverter which has unsymmetrical voltage and unsymmetrical current and spike wave.
 Lamp frequency may produce interface with horizontal synchronous frequency and as a result this may cause beat on the display. Therefore lamp frequency shall be as away possible from the horizontal synchronous frequency and from its harmonics in order to prevent interference.
8. Let's define the brightness of the lamp after being lighted for 5 minutes as 100%.
 T_g is the time required for the brightness of the center of the lamp to be not less than 95%.
 The used lamp current is the lamp typical current.
9. The lamp power consumption shown above does not include loss of external inverter.
 The used lamp current is the lamp typical current. ($P_{BL} = V_{BL} \times I_{BL} \times N_{Lamp}$)
10. The life is determined as the time at which brightness of the lamp is 50% compared to that of initial value at the typical lamp current on condition of continuous operating at $25 \pm 2^{\circ}C$.
11. Requirements for a system inverter design, which is intended to have a better display performance, a better power efficiency and a more reliable lamp, are following.
 It shall help increase the lamp lifetime and reduce leakage current.
 - a. The asymmetry rate of the inverter waveform should be less than 10%.
 - b. The distortion rate of the waveform should be within $\sqrt{2} \pm 10\%$.
 * Inverter output waveform had better be more similar to ideal sine wave.



* Asymmetry rate:

$$| I_p - I_{-p} | / I_{rms} \times 100\%$$

* Distortion rate

$$I_p \text{ (or } I_{-p}) / I_{rms}$$

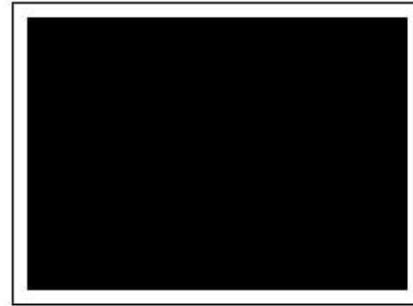
12. The inverter which is combined with this LCM, is highly recommended to connect coupling(ballast) condenser at the high voltage output side. When you use the inverter which has not coupling(ballast) condenser, it may cause abnormal lamp lighting because of biased mercury as time goes.
13. Permissive power ripple should be measured under $V_{LCD} = 12.0V$, $25^{\circ}C$, f_v (frame frequency)=MAX condition and At that time, we recommend the bandwidth configuration of oscilloscope is to be under 20Mhz. See the figure 3.
14. In case of edgy type back light with over 4 parallel lamps, input current and voltage wave form should be synchronized

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- **Permissive Power input ripple** ($V_{LCD} = 12.0V$, $25^{\circ}C$, fV (frame frequency)=MAX condition)

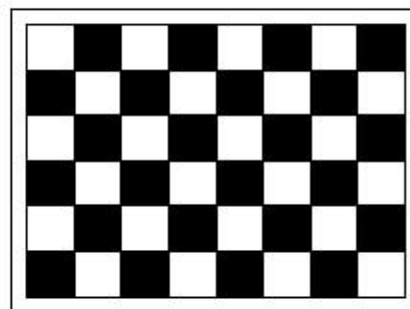


White pattern



Black pattern

- **Power consumption** ($V_{LCD} = 12V$, $25^{\circ}C$, fV (frame frequency)=60Hz condition)



Typical power Pattern

[Figure 3] Mosaic pattern & Black Pattern for power consumption measurement

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3-2. Interface Connections

3-2-1. LCD Module

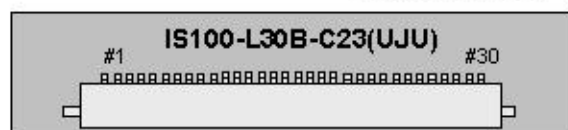
- LCD Connector(CN1) : FI-XB30SL-HF 11(JAE), MDF76LBRW-30S-1H (Hirose) , IS100-L30B-C23(UJU)
- Mating Connector : FI-XC30C2L (Manufactured by JAE) or Equivalent

Table 3 MODULE CONNECTOR(CN1) PIN CONFIGURATION

| No | Symbol | Description | No | Symbol | Symbol |
|----|---------|--|----|-------------|--|
| 1 | FR0M | Minus signal of odd channel 0 (LVDS) | 16 | SR1P | Plus signal of even channel 1 (LVDS) |
| 2 | FR0P | Plus signal of odd channel 0 (LVDS) | 17 | GND | Ground |
| 3 | FR1M | Minus signal of odd channel 1 (LVDS) | 18 | SR2M | Minus signal of even channel 2 (LVDS) |
| 4 | FR1P | Plus signal of odd channel 1 (LVDS) | 19 | SR2P | Plus signal of even channel 2 (LVDS) |
| 5 | FR2M | Minus signal of odd channel 2 (LVDS) | 20 | SCLKIN M | Minus signal of even clock channel (LVDS) |
| 6 | FR2P | Plus signal of odd channel 2 (LVDS) | 21 | SCLKINP | Plus signal of even clock channel (LVDS) |
| 7 | GND | Ground | 22 | SR3M | Minus signal of even channel 3 (LVDS) |
| 8 | FCLKINM | Minus signal of odd clock channel (LVDS) | 23 | SR3P | Plus signal of even channel 3 (LVDS) |
| 9 | FCLKINP | Plus signal of odd clock channel (LVDS) | 24 | GND | Ground |
| 10 | FR3M | Minus signal of odd channel 3 (LVDS) | 25 | NC | No Connection (I2C Serial interface for LCM) |
| 11 | FR3P | Plus signal of odd channel 3 (LVDS) | 26 | NC | No Connection.(I2C Serial interface for LCM) |
| 12 | SR0M | Minus signal of even channel 0 (LVDS) | 27 | PWM_OUT | For Control Burst frequency of Inverter |
| 13 | SR0P | Plus signal of even channel 0 (LVDS) | 28 | VLcd | Power Supply +12.0V |
| 14 | GND | Ground | 29 | VLcd | Power Supply +12.0V |
| 15 | SR1M | Minus signal of even channel 1 (LVDS) | 30 | VLcd | Power Supply +12.0V |

- Note:
1. All GND(ground) pins should be connected together and to Vss which should also be connected to the LCD's metal frame.
 2. All VLcd (power input) pins should be connected together.
 3. Input Level of LVDS signal is based on the IEA 664 Standard.
 4. PWM_OUT signal controls the burst frequency of a inverter.
 This signal is synchronized with vertical frequency.
 It's frequency is 3 times of vertical frequency, and it's duty ratio is 50%.
 If you don't use this pin, it is no connection.

[Figure 4] User Connector diagram



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Table 4. REQUIRED SIGNAL ASSIGNMENT FOR Flat Link (TI:SN75LVDS83) Transmitter

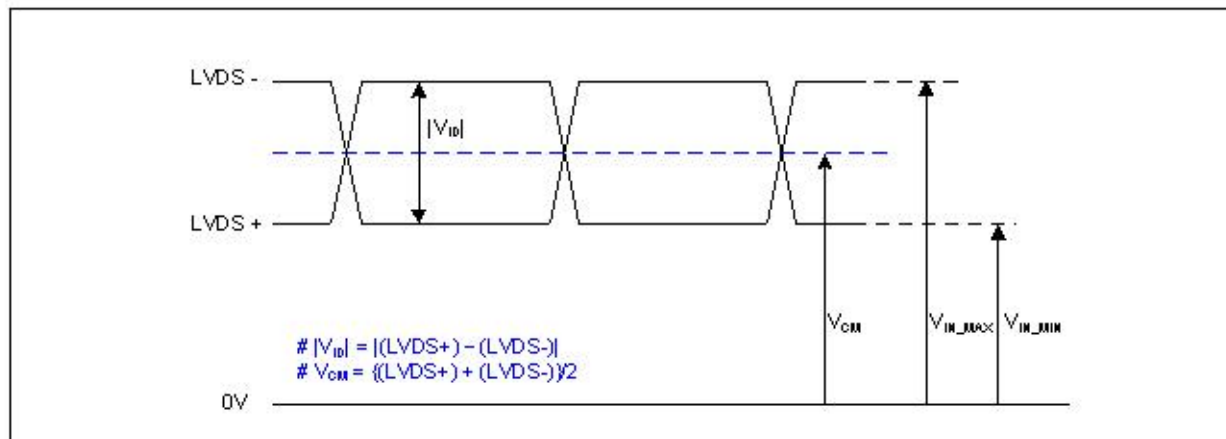
| Pin # | Pin Name | Require Signal | Pin # | Pin Name | Require Signal |
|-------|----------|----------------------------|-------|-------------------------|--|
| 1 | Vcc | Power Supply for TTL Input | 29 | GND | Ground pin for TTL |
| 2 | D5 | TTL Input (R7) | 30 | D26 | TTL Input (DE) |
| 3 | D6 | TTL Input (R5) | 31 | T _x CLKIN | TTL Level clock Input |
| 4 | D7 | TTL Input (G0) | 32 | PWR DWN | Power Down Input |
| 5 | GND | Ground pin for TTL | 33 | PLL GND | Ground pin for PLL |
| 6 | D8 | TTL Input (G1) | 34 | PLL Vcc | Power Supply for PLL |
| 7 | D9 | TTL Input (G2) | 35 | PLL GND | Ground pin for PLL |
| 8 | D10 | TTL Input (G6) | 36 | LVDS GND | Ground pin for LVDS |
| 9 | Vcc | Power Supply for TTL Input | 37 | T _x OUT3 + | Positive LVDS differential data output 3 |
| 10 | D11 | TTL Input (G7) | 38 | T _x OUT3 - | Negative LVDS differential data output 3 |
| 11 | D12 | TTL Input (G3) | 39 | T _x CLKOUT + | Positive LVDS differential clock output |
| 12 | D13 | TTL Input (G4) | 40 | T _x CLKOUT - | Negative LVDS differential clock output |
| 13 | GND | Ground pin for TTL | 41 | T _x OUT2 + | Positive LVDS differential data output 2 |
| 14 | D14 | TTL Input (G5) | 42 | T _x OUT2 - | Negative LVDS differential data output 2 |
| 15 | D15 | TTL Input (B0) | 43 | LVDS GND | Ground pin for LVDS |
| 16 | D16 | TTL Input (B6) | 44 | LVDS Vcc | Power Supply for LVDS |
| 17 | Vcc | Power Supply for TTL Input | 45 | T _x OUT1 + | Positive LVDS differential data output 1 |
| 18 | D17 | TTL Input (B7) | 46 | T _x OUT1 - | Negative LVDS differential data output 1 |
| 19 | D18 | TTL Input (B1) | 47 | T _x OUT0 + | Positive LVDS differential data output 0 |
| 20 | D19 | TTL Input (B2) | 48 | T _x OUT0 - | Negative LVDS differential data output 0 |
| 21 | GND | Ground pin for TTL Input | 49 | LVDS GND | Ground pin for LVDS |
| 22 | D20 | TTL Input (B3) | 50 | D27 | TTL Input (R6) |
| 23 | D21 | TTL Input (B4) | 51 | D0 | TTL Input (R0) |
| 24 | D22 | TTL Input (B5) | 52 | D1 | TTL Input (R1) |
| 25 | D23 | TTL Input (RSVD) | 53 | GND | Ground pin for TTL |
| 26 | Vcc | Power Supply for TTL Input | 54 | D2 | TTL Input (R2) |
| 27 | D24 | TTL Input (HSYNC) | 55 | D3 | TTL Input (R3) |
| 28 | D25 | TTL Input (VSYNC) | 56 | D4 | TTL Input (R4) |

Notes : 1. Refer to LVDS Transmitter Data Sheet for detail descriptions.
 2. 7 means MSB and 0 means LSB at R,G,B pixel data

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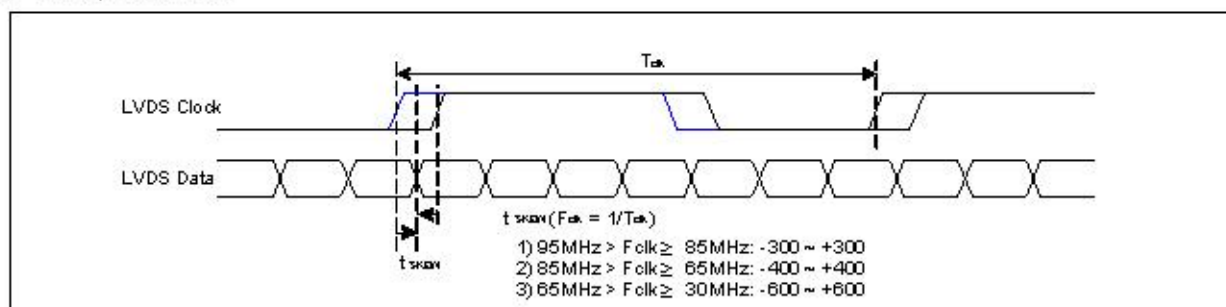
LVDS Input characteristics

1. DC Specification



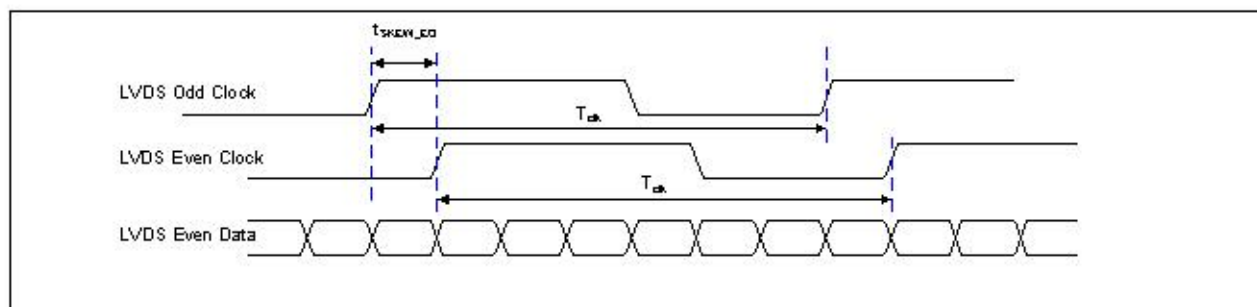
| Description | Symbol | Min | Max | Unit | Notes |
|---------------------------|------------|-----|-----|------|-------|
| LVDS Differential Voltage | $ V_{ID} $ | 100 | 600 | mV | - |
| LVDS Common mode Voltage | V_{CM} | 0.6 | 1.8 | V | - |
| LVDS Input Voltage Range | V_{IN} | 0.3 | 2.1 | V | - |

2. AC Specification



| Description | Symbol | Min | Max | Unit | Notes |
|---|----------------------|-------|-------|------------------|----------------------------------|
| LVDS Clock to Data Skew Margin | t _{skew} | - 300 | + 300 | ps | 95MHz > F _{clk} ≥ 85MHz |
| | t _{skew} | - 400 | + 400 | ps | 85MHz > F _{clk} ≥ 65MHz |
| | t _{skew} | - 600 | + 600 | ps | 65MHz > F _{clk} ≥ 30MHz |
| LVDS Clock to Clock Skew Margin (Even to Odd) | t _{skew_EO} | - 1/7 | + 1/7 | T _{clk} | - |

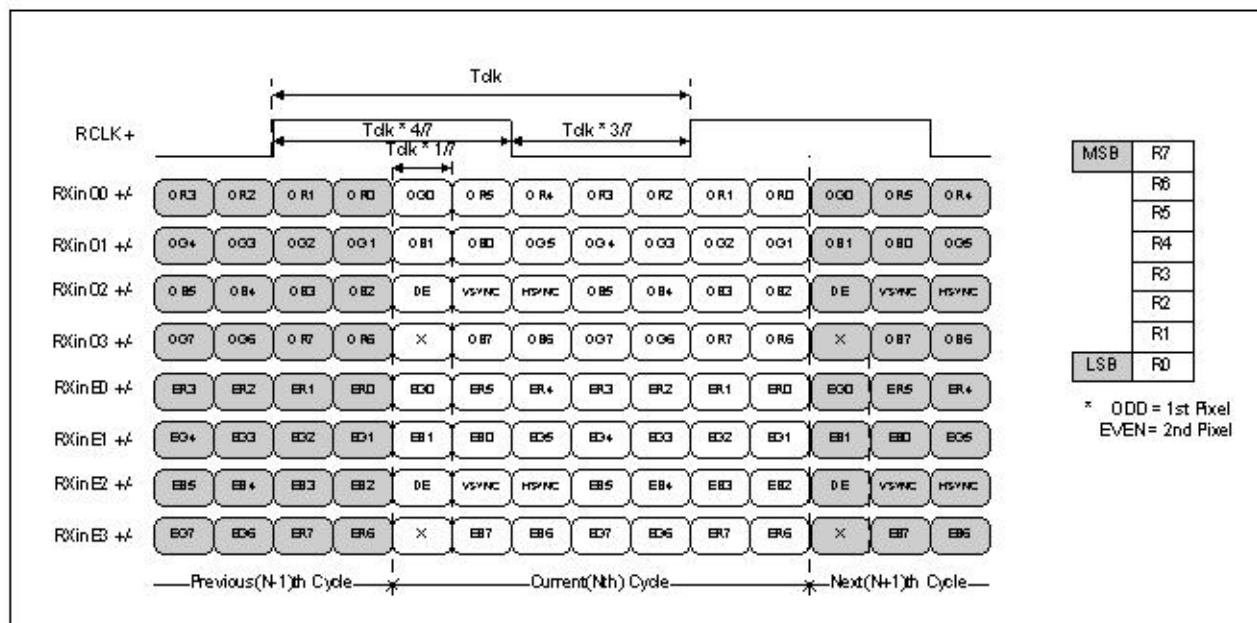
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< Clock skew margin between channel >

3. Data Format

1) LVDS 2 Port



< LVDS Data Format >

Product Specification
Table 5. BACKLIGHT CONNECTOR PIN CONFIGURATION(CN2,CN3,CN4,CN5)

The backlight interface connector is a model 35001HS-02LD manufactured by Yeonho. The mating connector part number are 35001WR-02L or equivalent. The pin configuration for the connector is shown in the table below.

| Pin | Symbol | Description | NOTES |
|-----|--------|-----------------------|-------|
| 1 | HV | High Voltage for Lamp | 1 |
| 2 | LV | Low Voltage for Lamp | 1, 2 |

- Note :
1. The high voltage power terminal is colored White, Pink
The low voltage pin color is White, Blue.
 2. The backlight ground should be common with LCD metal frame.
 3. 35001HS-02LD (Locking type)

Up Side

Down Side

[Figure 5] Backlight connector diagram

Product Specification
3-3. Signal Timing Specifications

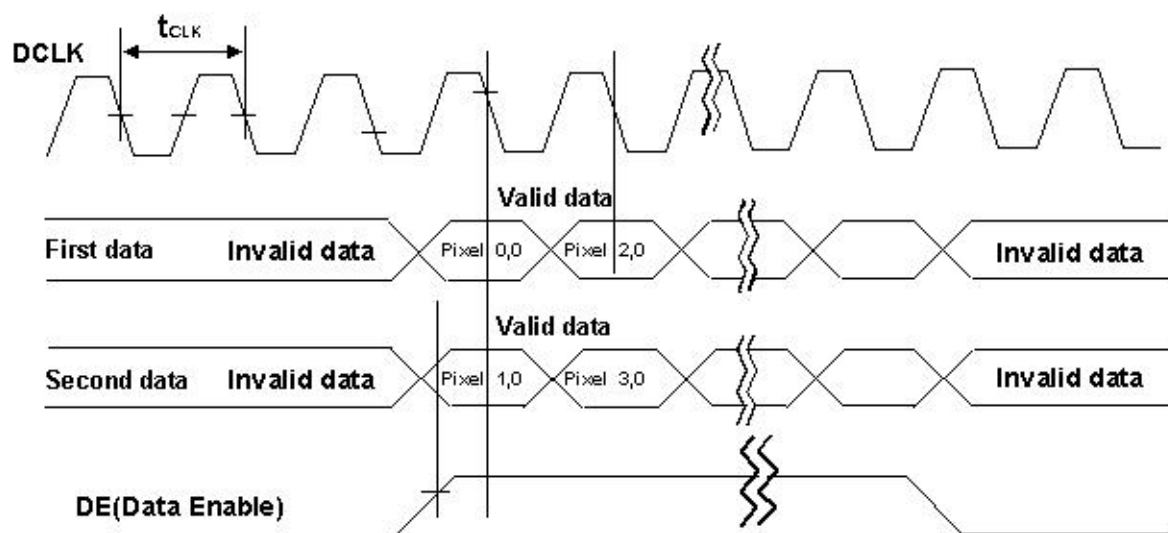
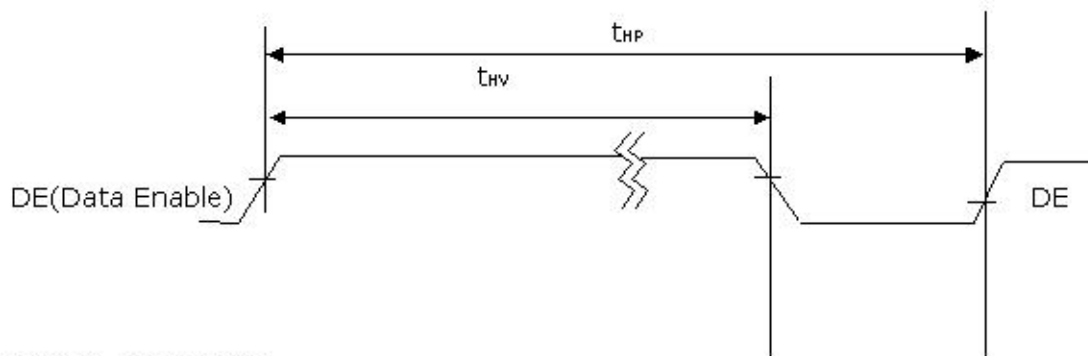
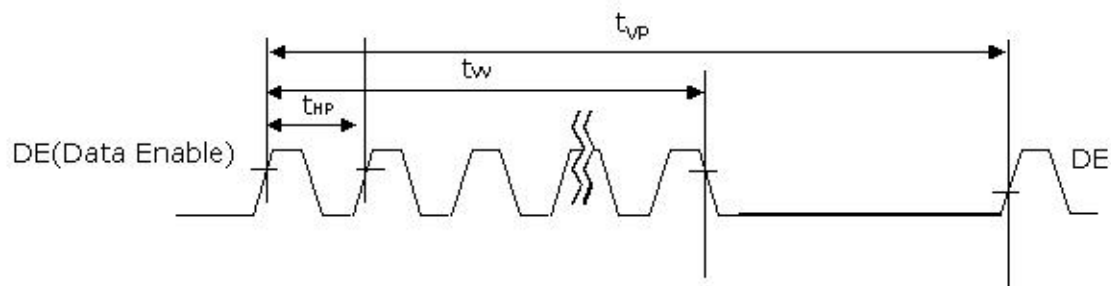
This is signal timing required at the input of the TMDS transmitter. All of the interface signal timing should be satisfied with the following specifications for it's proper operation.

Table 6. TIMING TABLE

| ITEM | Symbol | | Min | Typ | Max | Unit | Note |
|------------|-----------|------|-------|-------|-------|--------|------|
| DCLK | Period | tCLK | 11.76 | 13.89 | 15.38 | ns | |
| | Frequency | - | 60 | 72 | 87.5 | MHz | |
| Horizontal | total | tHP | 1000 | 1088 | 1120 | tCLK | |
| | Frequency | fH | 64 | 66 | 83 | KHz | |
| | Blanking | | 40 | 128 | 160 | tCLK | |
| | valid | tWH | 960 | 960 | 960 | tCLK/2 | |
| Vertical | total | tVP | 1090 | 1100 | 1160 | tHP | |
| | Frequency | fV | 50 | 60 | 75 | Hz | |
| | Blanking | | 10 | 20 | 80 | tHP | |
| | valid | tWV | 1080 | 1080 | 1080 | tHP | |

Note:

1. DE Only mode operation. The input of Hsync & Vsync signal does not have an effect on LCD normal operation.
2. The performance of the electro-optical characteristics may be influenced by variance of the vertical refresh rates.
3. Horizontal period should be even.

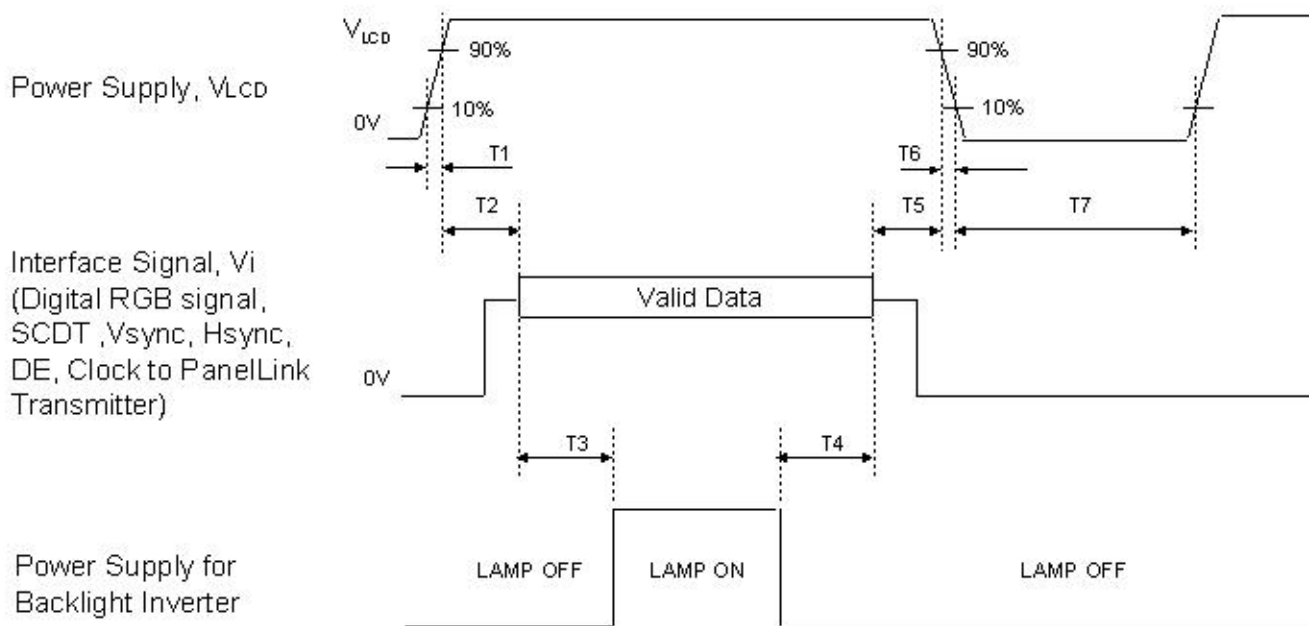
Product Specification
3-4. Signal Timing Waveforms
1. DCLK, DE, DATA waveforms

2. Horizontal waveform

3. Vertical waveform


Product Specification
3-5. Color Input Data Reference

The Brightness of each primary color(red,green,blue) is based on the 8-bit gray scale data input for the color; the higher the binary input, the brighter the color. The table below provides a reference for color versus data input.

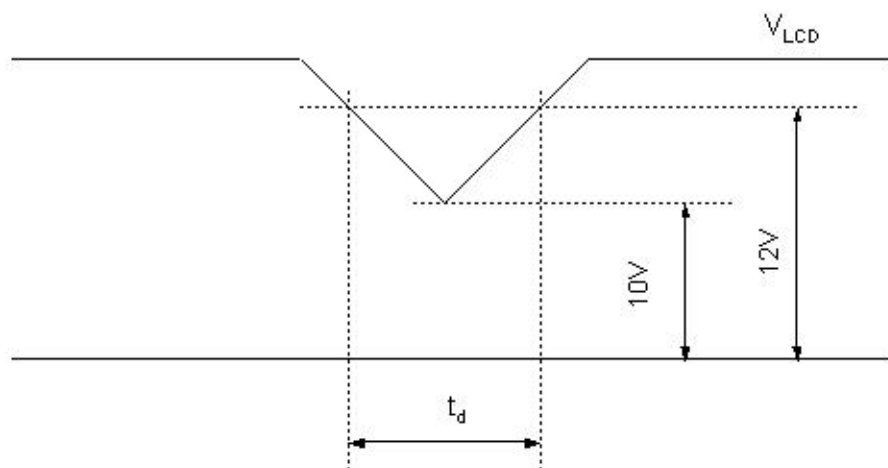
Table 7. COLOR DATA REFERENCE

| Color | | Input Color Data | | | | | | | | | | | | | | | | | | | | | | | | |
|-------------|------------------|------------------|----|----|----|-----|----|----|----|-------|----|----|----|-----|----|----|----|------|----|----|----|-----|----|----|----|---|
| | | RED | | | | | | | | GREEN | | | | | | | | BLUE | | | | | | | | |
| | | MSB | | | | LSB | | | | MSB | | | | LSB | | | | MSB | | | | LSB | | | | |
| | | R7 | R6 | R5 | R4 | R3 | R2 | R1 | R0 | G7 | G6 | G5 | G4 | G3 | G2 | G1 | G0 | B7 | B6 | B5 | B4 | B3 | B2 | B1 | B0 | |
| Basic Color | Black | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| | Red (255) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| | Green (255) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| | Blue (255) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| | Cyan | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| | Magenta | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | Yellow | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| | White | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| RED | RED (000) Dark | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| | RED (001) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| | ... | ... | | | | | | | | ... | | | | | | | | ... | | | | | | | | |
| | RED (254) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| | RED (255) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| GREEN | GREEN (000) Dark | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| | GREEN (001) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| | ... | ... | | | | | | | | ... | | | | | | | | ... | | | | | | | | |
| | GREEN (254) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| | GREEN (255) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| BLUE | BLUE (000) Dark | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| | BLUE (001) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | |
| | ... | ... | | | | | | | | ... | | | | | | | | ... | | | | | | | | |
| | BLUE (254) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | |
| | BLUE (255) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |

Product Specification
3-6. Power Sequence

[Figure 6] Power sequence
Table 8. POWER SEQUENCE

| Parameter | Values | | | Units |
|-----------|--------|-----|-----|-------|
| | Min | Typ | Max | |
| T1 | 0.5 | - | 10 | ms |
| T2 | 0.01 | - | 50 | ms |
| T3 | 500 | - | - | ms |
| T4 | 200 | - | - | ms |
| T5 | 0.01 | - | 50 | ms |
| T7 | 1000 | | - | ms |

- Notes :
1. Please avoid floating state of interface signal at invalid period.
 2. When the interface signal is invalid, be sure to pull down the power supply for LCD V_{LCD} to 0V.
 3. Lamp power must be turn on after power supply for LCD and interface signal are valid.

3-7. V_{LCD} Power Dip Condition


[Figure 7] Power dip condition

1) Dip condition

$$10V \leq V_{LCD} < 11V, \quad t_d \leq 20ms$$

2) $V_{LCD} < 10V$

V_{LCD} -dip conditions should also follow the Power On/Off conditions for supply voltage.

Product Specification

4. Optical Specifications

Optical characteristics are determined after the unit has been 'ON' for approximately 30 minutes in a dark environment at $25 \pm 2^\circ\text{C}$. The values specified are at an approximate distance 50cm from the LCD surface at a viewing angle of Φ and θ equal to 0° and aperture 1 degree.

FIG. 1 presents additional information concerning the measurement equipment and method.

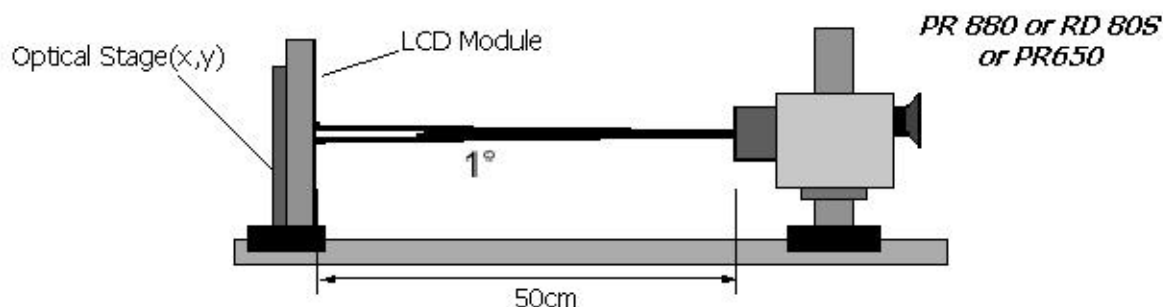


FIG. 1 Optical Characteristic Measurement Equipment and Method

Table 9. OPTICAL CHARACTERISTICS

($T_a = 25^\circ\text{C}$, $V_{\text{LCD}} = 12\text{V}$, $f_v = 60\text{Hz}$ Dclk=144MHz, IBL=7.5mA)

| Parameter | | Symbol | Values | | | Units | Notes |
|---|---------------------|----------------------------|--------------|----------|--------------|-------------------|-------|
| | | | Min | Typ | Max | | |
| Contrast Ratio | | CR | 600 | 1000 | - | | 1 |
| Surface Luminance, white | | L_{WH} | 200 | 250 | - | cd/m ² | 2 |
| Luminance Variation | | δ_{WHITE} | 75 | - | - | % | 3 |
| Response Time | Gray To Gray | $T_{\text{GTG_AVG}}$ | - | 14 | 25 | ms | 4 |
| Color Coordinates [CIE1931] <i>(By PR650)</i> | RED | Rx | Typ -0.03 | TBD | Typ +0.03 | | |
| | | Ry | | TBD | | | |
| | GREEN | Gx | | TBD | | | |
| | | Gy | | TBD | | | |
| | BLUE | Bx | | TBD | | | |
| | | By | | TBD | | | |
| | WHITE | Wx | | 0.313 | | | |
| | | Wy | | 0.329 | | | |
| Color Shift <i>(Avg. $\Delta u'v' < 0.2$)</i> | Horizontal | $\theta_{\text{CST_H}}$ | - | 140 | - | Degree | 5 |
| | Vertical | $\theta_{\text{CST_V}}$ | - | 100 | - | | |
| Viewing Angle (CR>10) | | | | | | | |
| General | Horizontal | θ_{H} | 170 | 178 | - | Degree | 6 |
| | Vertical | θ_{V} | 170 | 178 | - | | |
| GSR @ 60dgree <i>(Gamma shift rate)</i> | Horizontal | $\delta_{\text{Gamma_H}}$ | - | - | 20 | % | 7 |
| | Vertical | $\delta_{\text{Gamma_V}}$ | - | - | 20 | | |
| WPT (White Point Tracking) | | - | -300 | G255 CCT | +700 | K | 8 |
| Color gamut (CG, CIE1976) | | | - | 82 | - | % | |
| Gray Scale | | - | | 2.2 | | | 9 |

Product Specification

Notes 1. Contrast Ratio(CR) is defined mathematically as : **(By PR880)**

$$\text{Contrast Ratio} = \frac{\text{Surface Luminance with all white pixels}}{\text{Surface Luminance with all black pixels}}$$

It is measured at center point(Location P1)

2. Surface luminance(L_{WH})is luminance value at Center 1 point(P1) across the LCD surface 50cm from the surface with all pixels displaying white. For more information see FIG 2. **(By PR880)**

3. The variation in surface luminance , δ_{WHITE} is defined as : **(By PR880)**

$$\delta_{WHITE} = \frac{\text{Minimum}(L_{P1}, L_{P2}, \dots, L_{P9})}{\text{Maximum}(L_{P1}, L_{P2}, \dots, L_{P9})} \times 100$$

Where L1 to L9 are the luminance with all pixels displaying white at 9 locations.
 For more information see FIG 2.

4. Gray to gray response time is the time required for the display to transition from gray to gray. For additional information see Table 10. **(By RD80S)**

5. Color shift is the angle at which the average color difference for all Macbeth is lower than 0.02.

For more information see FIG 3 and FIG 4. **(By EZ Contrast)**

- Color difference ($\Delta u'v'$)

$$u' = \frac{4x}{-2x + 12y + 3} \quad v' = \frac{9y}{-2x + 12y + 3} \quad \Delta u'v' = \sqrt{(u'_1 - u'_2)^2 + (v'_1 - v'_2)^2}$$

$$\text{Avg}(\Delta u'v') = \frac{\sum_{i=1}^{24} (\Delta u'v')_i}{24}$$

u'_1, v'_1 : $u'v'$ value at viewing angle direction
 u'_2, v'_2 : $u'v'$ value at front ($\Theta=0$)
 i : Macbeth chart number (Define 23 page)

- Pattern size : 25% Box size

- Viewing angle direction of color shift : Horizontal, Vertical

6. Viewing angle is the angle at which the contrast ratio is greater than 10. The angles are determined for the horizontal or x axis and the vertical or y axis with respect to the z axis which is normal to the LCD surface. For more information see FIG 4. **(By PR880)**

7. GSR is the rate of gamma shift at up, down, left and right 60 degree viewing angle compare with center gamma. For more information see FIG 5 and FIG 6 **(By EZ Contrast)**

- GSR (δ_{Gamma}) is defined as :

$$GSR = \frac{\text{View angle Gamma Value (Up, Down, Reft, Light 60 Degree)}}{\text{Center Gamma Value (0 Degree)}} \times 100$$

8. WPT (White Point Tracking) is the variation of color temperature between G255 and G63.

(By PR650)

Product Specification

Notes 9. Gamma Value is approximately 2.2. For more information see Table 11.

Measuring point for surface luminance & measuring point for luminance variation.

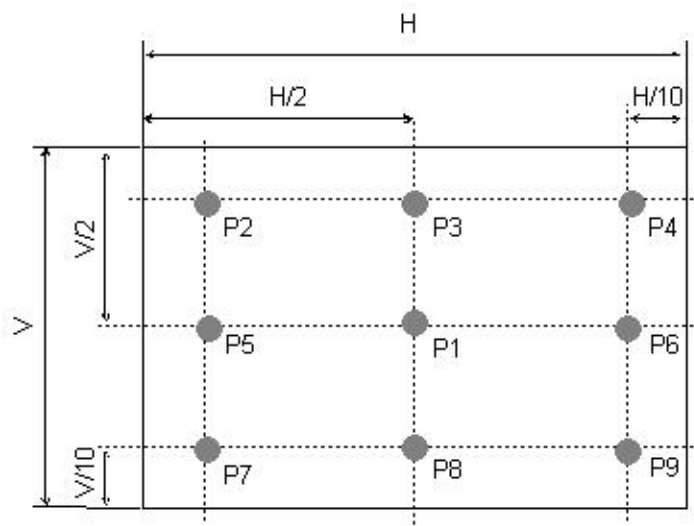


FIG. 2 Measure Point for Luminance

The Gray to Gray response time is defined as the following figure and shall be measured by switching the input signal for "Gray To Gray".

- Gray step : 5 Step
- TGTG_AVG is the total average time at rising time and falling time for "Gray To Gray".
- if system use ODC (Over Driving Circuit) function, Gray to Gary response time may be 5ms~8ms GtG
- * it depends on Overshoot rate.

Table. 10 GTG Gray Table

| Gray to Gray | | Rising Time | | | | |
|--------------|------|-------------|------|------|-----|----|
| | | G255 | G191 | G127 | G63 | G0 |
| Falling Time | G255 | | | | | |
| | G191 | | | | | |
| | G127 | | | | | |
| | G63 | | | | | |
| | G0 | | | | | |

Product Specification

Color shift is defined as the following test pattern and color.

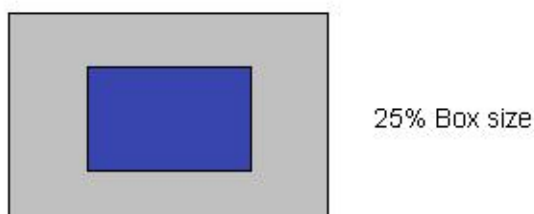


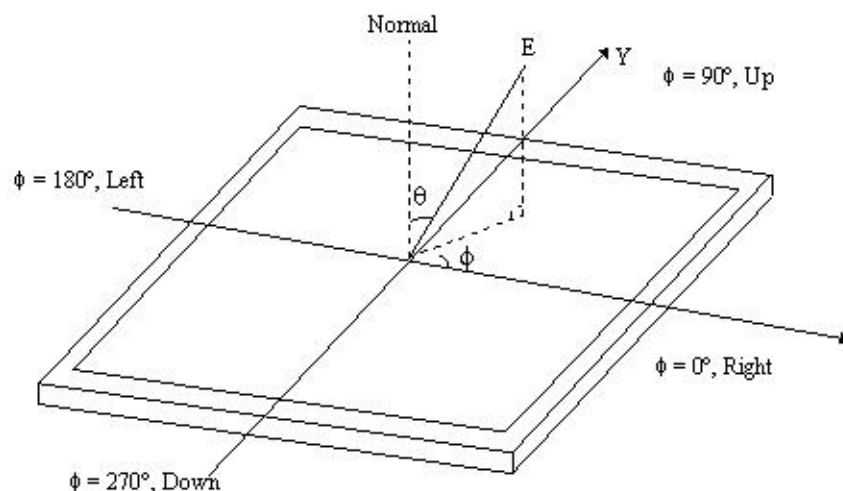
FIG. 3 Color Shift Test Pattern

Average RGB values in Bruce RGB for Macbeth Chart

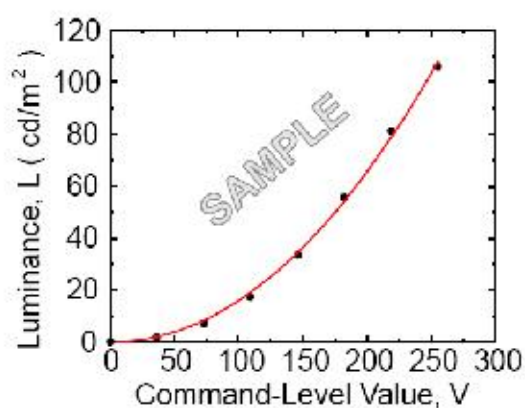
| | Dark skin (≒1) | Light skin | Blue sky | Foliage | Blue flower | Bluish green |
|---|----------------|---------------|--------------|-----------|--------------|---------------|
| R | 98 | 206 | 85 | 77 | 129 | 114 |
| G | 56 | 142 | 112 | 102 | 118 | 199 |
| B | 45 | 123 | 161 | 46 | 185 | 178 |
| | Orange | Purplish blue | Moderate red | Purple | Yellow green | Orange yellow |
| R | 219 | 56 | 211 | 76 | 160 | 230 |
| G | 104 | 69 | 67 | 39 | 193 | 162 |
| B | 24 | 174 | 87 | 86 | 58 | 29 |
| | Blue | Green | Red | Yellow | Magenta | Cyan |
| R | 26 | 72 | 197 | 241 | 207 | 35 |
| G | 32 | 148 | 27 | 212 | 62 | 126 |
| B | 145 | 65 | 37 | 36 | 151 | 172 |
| | White | Neutral 8 | Neutral 6.5 | Neutral 5 | Neutral 3.5 | Black |
| R | 240 | 206 | 155 | 110 | 63 | 22 |
| G | 240 | 206 | 155 | 110 | 63 | 22 |
| B | 240 | 206 | 155 | 110 | 63 | 22 |

Product Specification

Dimension of viewing angle range.

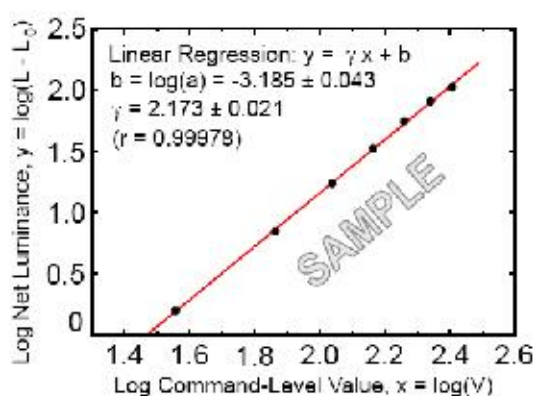


[FIG 12] Viewing angle



[FIG 13] Sample Luminance vs. gray scale
(using a 256 bit gray scale)

$$L = aV^{\gamma} + L_b$$



[FIG 14] Sample Log-log plot of
luminance vs. gray scale

$$\log(L - L_b) = \gamma \log(V) + \log(a)$$

Here the Parameter a and γ relate the signal level V to the luminance L .

The GAMMA we calculate from the log-log representation (FIG. 7)

Product Specification
Table 10. Gray Scale Specification

| Gray Level | Relative Luminance [%] (Typ.) |
|------------|-------------------------------|
| 0 | 0.11 |
| 31 | 1.08 |
| 63 | 4.72 |
| 95 | 11.49 |
| 127 | 21.66 |
| 159 | 35.45 |
| 191 | 53.00 |
| 223 | 74.48 |
| 255 | 100 |

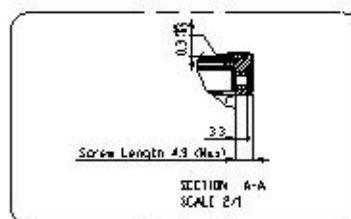
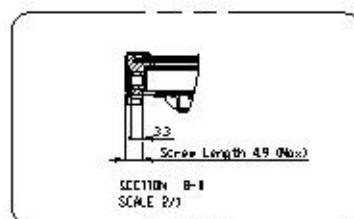
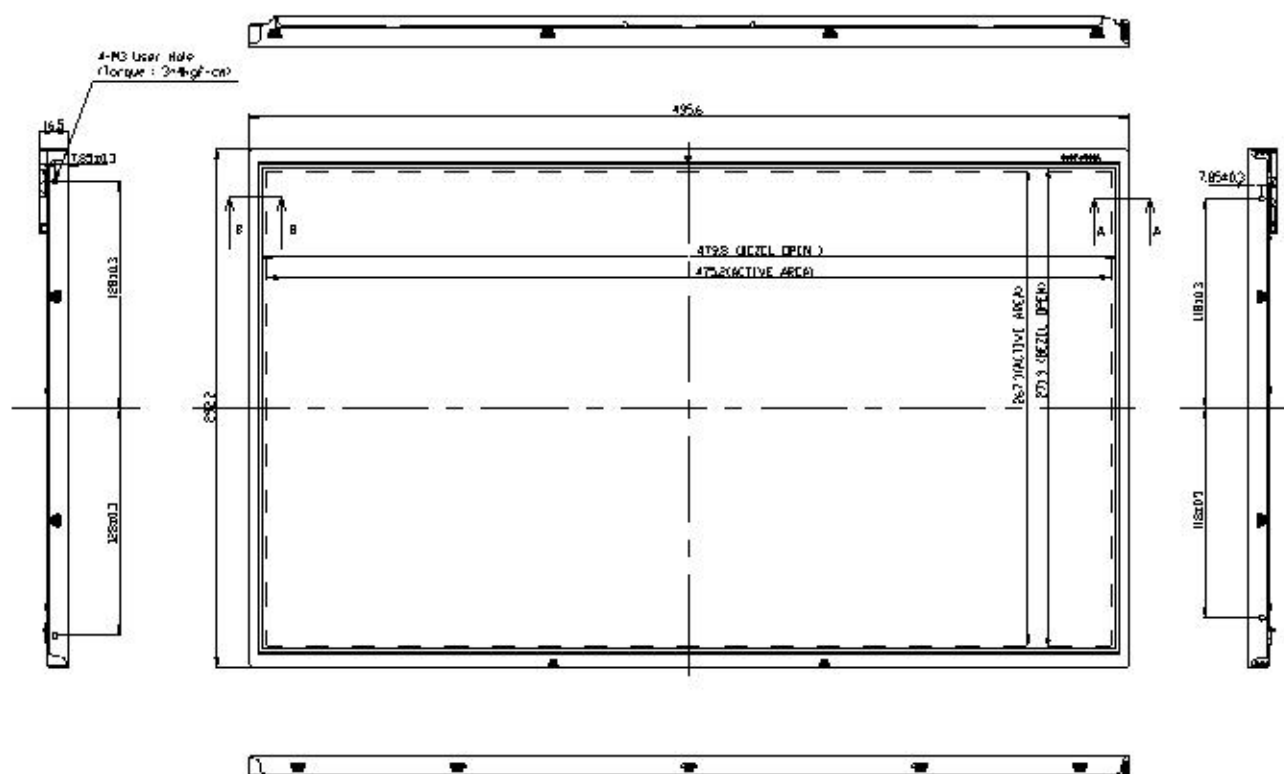
Product Specification
5. Mechanical Characteristics

The contents provide general mechanical characteristics. In addition the figures in the next page are detailed mechanical drawing of the LCD.

| | | |
|---------------------|---|----------|
| Outline Dimension | Horizontal | 495.6mm |
| | Vertical | 292.2mm |
| | Depth | 16.5mm |
| Bezel Area | Horizontal | 479.84mm |
| | Vertical | 272.31mm |
| Active Display Area | Horizontal | 475.2mm |
| | Vertical | 267.3mm |
| Weight | Typ : TBD g , Max : TBD g | |
| Surface Treatment | Hard coating(3H) Anti-glare treatment of the front polarizer | |

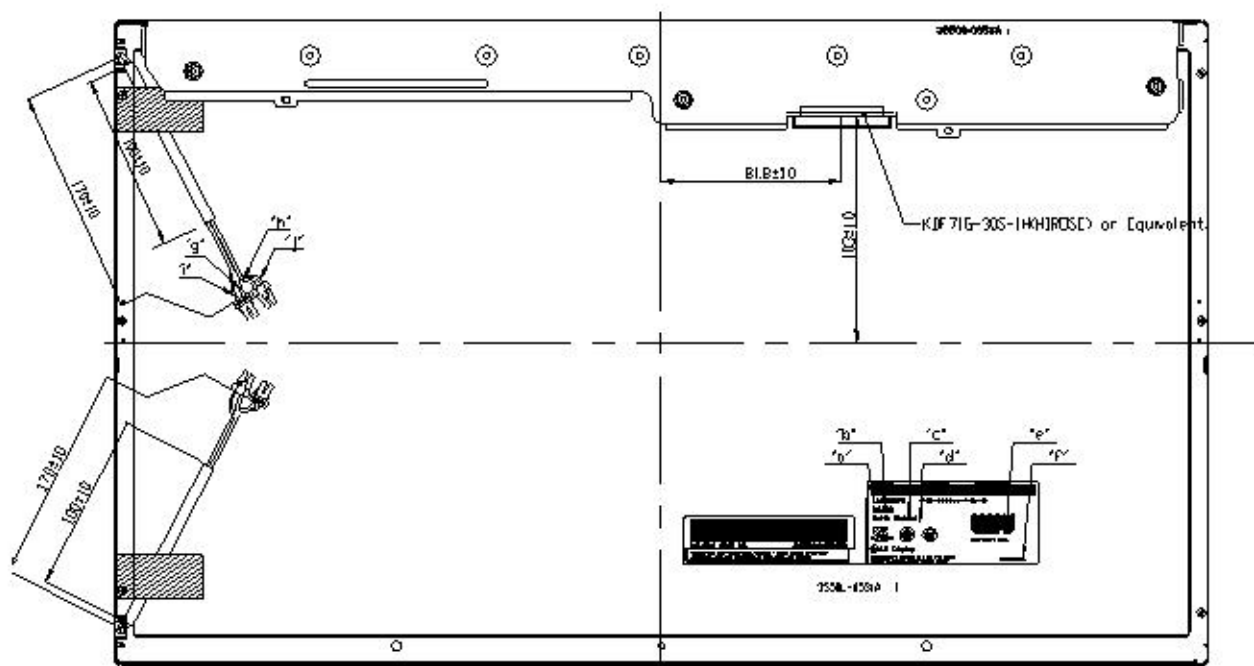
Notes : Please refer to a mechanic drawing in terms of tolerance at the next page.

<FRONT VIEW>



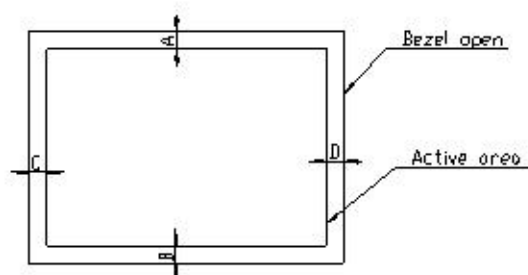
Product Specification

<REAR VIEW>



Notes

1. Unspecified tolerances to be $\pm 0.5\text{mm}$
2. Backlight : 4 Cold Cathode Fluorescent Lamps.
3. I/F Connector Specification : KDF 71G-30S-1H or Equivalent
4. Torque of user hole : 3.0-4.0 kgf-cm
5. Tilt and partial disposition tolerance of display area as following
 - (1) Y-Direction : 1A-1B ≤ 1.0
 - (2) X-Direction : 1C-1D ≤ 1.0



7. Do not wind conductive tape around the backlight wires
8. Gap between Bezel and Panel : Max 0.8mm

Product Specification
6. Reliability

Environment test condition

| No | Test Item | Condition |
|----|--|--|
| 1 | High temperature storage test | Ta= 60°C 240h |
| 2 | Low temperature storage test | Ta= -20°C 240h |
| 3 | High temperature operation test | Ta= 50°C 50%RH 240h |
| 4 | Low temperature operation test | Ta= 0°C 240h |
| 5 | Vibration test (non-operating) | Wave form : random Vibration level : 1.00G RMS Bandwidth : 10-300Hz Duration : X, Y, Z, 10 min One time each direction |
| 6 | Shock test (non-operating) | Shock level : 100G Waveform : half sine wave, 2ms Direction : $\pm X$, $\pm Y$, $\pm Z$ One time each direction |
| 7 | Humidity condition Operation | Ta= 40 °C ,90%RH |
| 8 | Altitude storage / shipment | 0 - 40,000 feet(12192m) |
| 9 | Maximum Storage Humidity for 4 corner light leakage Mura. | Max 70%RH , Ta=40°C |

Product Specification**7. International Standards****7-1. Safety**

- a) UL 60950-1:2003, First Edition, Underwriters Laboratories, Inc.,
Standard for Safety of Information Technology Equipment.
- b) CAN/CSA C22.2, No. 60950-1-03 1st Ed. April 1, 2003, Canadian Standards Association,
Standard for Safety of Information Technology Equipment.
- c) EN 60950-1:2001, First Edition,
European Committee for Electrotechnical Standardization(CENELEC)
European Standard for Safety of Information Technology Equipment.

7-2. EMC

- a) ANSI C63.4 "Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electrical Equipment in the Range of 9kHz to 40GHz." American National Standards Institute(ANSI), 1992
- b) C.I.S.P.R "Limits and Methods of Measurement of Radio Interface Characteristics of Information Technology Equipment." International Special Committee on Radio Interference.
- c) EN 55022 "Limits and Methods of Measurement of Radio Interface Characteristics of Information Technology Equipment." European Committee for Electrotechnical Standardization.(CENELEC), 1998
(Including A1: 2000)

7-3. Environment

- a) RoHS. Directive 2002/95/EC of the European Parliament and of the Council on the reduction of the use of certain hazardous substances in electrical and electronic equipment. January 2003

Product Specification

8. Packing

8-1. Designation of Lot Mark

a) Lot Mark

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | B | C | D | E | F | G | H | I | J | K | L | M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|

A,B,C : SIZE(INCH)

E : MONTH

D : YEAR

F ~ M : SERIAL NO.

Note

1. YEAR

| | | | | | | | | | | |
|------|------|------|------|------|------|------|------|------|------|------|
| Year | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
| Mark | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 0 |

2. MONTH

| | | | | | | | | | | | | |
|-------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Month | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| Mark | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | A | B | C |

b) Location of Lot Mark

Serial No. is printed on the label. The label is attached to the backside of the LCD module.
 This is subject to change without prior notice.

8-2. Packing Form

a) Package quantity in one box : TBD

b) Box Size : TBD

Product Specification**9. PRECAUTIONS**

Please pay attention to the followings when you use this TFT LCD module.

9-1. MOUNTING PRECAUTIONS

- (1) You must mount a module using holes arranged in four corners or four sides.
- (2) You should consider the mounting structure so that uneven force (ex. Twisted stress) is not applied to the module. And the case on which a module is mounted should have sufficient strength so that external force is not transmitted directly to the module.
- (3) Please attach the surface transparent protective plate to the surface in order to protect the polarizer. Transparent protective plate should have sufficient strength in order to resist external force.
- (4) You should adopt radiation structure to satisfy the temperature specification.
- (5) Acetic acid type and chlorine type materials for the cover case are not desirable because the former generates corrosive gas of attacking the polarizer at high temperature and the latter causes circuit break by electro-chemical reaction.
- (6) Do not touch, push or rub the exposed polarizers with glass, tweezers or anything harder than HB pencil lead. And please do not rub with dust clothes with chemical treatment. Do not touch the surface of polarizer for bare hand or greasy cloth. (Some cosmetics are detrimental to the polarizer.)
- (7) When the surface becomes dusty, please wipe gently with absorbent cotton or other soft materials like chamois soaks with petroleum benzene. Normal-hexane is recommended for cleaning the adhesives used to attach front / rear polarizers. Do not use acetone, toluene and alcohol because they cause chemical damage to the polarizer.
- (8) Wipe off saliva or water drops as soon as possible. Their long time contact with polarizer causes deformations and color fading.
- (9) Do not open the case because inside circuits do not have sufficient strength.

9-2. OPERATING PRECAUTIONS

- (1) The spike noise causes the mis-operation of circuits. It should be lower than following voltage :
 $V = \pm 200\text{mV}$ (Over and under shoot voltage)
- (2) Response time depends on the temperature. (In lower temperature, it becomes longer.)
- (3) Brightness depends on the temperature. (In lower temperature, it becomes lower.)
And in lower temperature, response time (required time that brightness is stable after turned on) becomes longer.
- (4) Be careful for condensation at sudden temperature change. Condensation makes damage to polarizer or electrical contacted parts. And after fading condensation, smear or spot will occur.
- (5) When fixed patterns are displayed for a long time, remnant image is likely to occur.
- (6) Module has high frequency circuits. Sufficient suppression to the electromagnetic interference shall be done by system manufacturers. Grounding and shielding methods may be important to minimize the interference.
- (7) Please do not give any mechanical and/or acoustical impact to LCM. Otherwise, LCM can't be operated its full characteristics perfectly.
- (8) A screw which is fastened up the steels should be a machine screw.
(if not, it causes metallic foreign material and deal LCM a fatal blow)
- (9) Please do not set LCD on its edge.
- (10) When LCMs are used for public display(over than 20hrs usage per day) defects such as Yogure, image sticking can not be guarantee.**

Product Specification**9-3. ELECTROSTATIC DISCHARGE CONTROL**

Since a module is composed of electronic circuits, it is not strong to electrostatic discharge. Make certain that treatment persons are connected to ground through wrist band etc. And don't touch interface pin directly.

9-4. PRECAUTIONS FOR STRONG LIGHT EXPOSURE

Strong light exposure causes degradation of polarizer and color filter.

9-5. STORAGE

When storing modules as spares for a long time, the following precautions are necessary.

- (1) Store them in a dark place. Do not expose the module to sunlight or fluorescent light. Keep the temperature between 5°C and 35°C at normal humidity.
- (2) The polarizer surface should not come in contact with any other object.
It is recommended that they be stored in the container in which they were shipped.

9-6. HANDLING PRECAUTIONS FOR PROTECTION FILM

- (1) The protection film is attached to the bezel with a small masking tape.
When the protection film is peeled off, static electricity is generated between the film and polarizer.
This should be peeled off slowly and carefully by people who are electrically grounded and with well ion-blown equipment or in such a condition, etc.
- (2) When the module with protection film attached is stored for a long time, sometimes there remains a very small amount of glue still on the bezel after the protection film is peeled off.
- (3) You can remove the glue easily. When the glue remains on the bezel surface or its vestige is recognized, please wipe them off with absorbent cotton waste or other soft material like chamois soaked with normal-hexane.